ATS-16105

DEPARTMENT OF

PHYSICS

GRAMBLING COLLEGE

Grambling, Louisiana

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Semi-Annual Status Report

for a

STUDY OF LOW FREQUENCY HYDROMAGNETIC WAVES USING ATS-1 DATA (NGR-19-011-007)

by

W. D. Cummings
Department of Physics
Grambling College

December 19, 1973

SEMI-ANNUAL STATUS REPORT:

SUBMITTED TO:	NASA Scientific and Technical Information Facility P. O. Box 33 College Park, Maryland 20740
REFERENCE NUMBER:	NGR-19-011-007 Supplement No. 2
INSTITUTION:	Grambling College Grambling, Louisiana 71245
TITLE:	A Propcsal to Continue Studying Low Frequency Hydromagnetic Waves Using ATS-1 Data
PRINCIPAL INVESTIGATOR:	W. D. Cummings, Professor Department of Physics
DURATION:	
(Original Grant)	One (1) Year
(Supplement No. 1)	One (1) Year
(Supplement No. 2)	One (1) Year
SUM GRANTED BY NASA:	
(Original Grant)	\$11,421
(Supplement No. 1)	\$11,987
(Supplement No. 2)	\$11,997
DATE:	
(Original Grant)	December 1, 1970
(Supplement No. 1)	December 1, 1971
(Supplement No. 2)	December 1, 1972
(This Report)	December 19, 1973
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Introduction:

I would like to devote this report to a discussion of a research problem that Calvin Countee (a student) is pursuing. The idea behind the problem is that perhaps the low-frequency oscillations observed at ATS-1 are the result of an attempt by the magnetospheric plasma to conserve its angular momentum as it convects through the magnetosphere.

Discussion:

Let's consider a particle that mirrors in the equatorial plane. The conservation of the first adiabatic invariant means that

$$w_{\perp}/B = \text{const.} = \mu$$

or

$$\tfrac{1}{2}mv^2 = \mu B$$

The angular momentum of the particle about its guiding center is

$$l = mvr$$

But r is the gyroradius given by

$$r = mv/qB.$$

Hence

$$l = m^2 v^2/qB$$

or

$$l = 2m\mu/q = \text{const.}$$

Thus the angular momentum of the particle about its guiding center is constant, if the first adiabatic invariant is conserved.

The next thing to consider is the angular momentum associated with the convective flow of the plasma through the magnetosphere. Following Kavanagh et al. (1968) we suppose the convective flow of the plasma is due to crossed electric and magnetic fields, where the electric field consists of a co-rotating component and to a solar wind component.

$$\vec{E}_{cr} = -\omega BR\hat{e}_r$$

$$\vec{E}_{sw} = C\hat{e}_y,$$

where ω is the angular frequency of rotation of the earth, B is the magnetic field at the position of the particle, and R is the geocentric distance to the particle. We will use a coordinate system where the Z axis is perpendicular to the geomagnetic equatorial plane of the earth, the X axis is in the solar meridian. Then assuming a dipole magnetic field, we have

$$\vec{E}_{cr} = \frac{-\omega B_o R_E^3}{R^3} \; (\hat{e}_x \, x + \hat{e}_y y)$$

$$\vec{E}_{SW} = C\hat{e}y$$

$$\vec{v}_c = \frac{\vec{E} \times \vec{B}}{B^2} = \left(\frac{C\ R^3}{B_o R_E{}^3} - \omega y\right) \hat{e}_x + \omega x\ \hat{e}y$$

Now the angular momentum associated with a bulk equatorial flow velocity $\vec{V}$ is

$$\vec{L} = \vec{r} \times m\vec{V} = m(x\ Vy - y\ V_x)$$

If $\vec{L}$ is to be constant, we must have

$$x\ V_y = y\ V_x + \text{Const}$$

For the convective flow above, we have

$$\omega X^2 \overset{?}{=} \frac{yCR^3}{B_o R_E{}^3} - \omega y^2 + \text{Const}$$

or

$$\omega R^2 \overset{?}{=} \frac{yCR^3}{B_o R_E{}^3} + \text{Const.}$$

Remaining Questions:

We are still seeking answers to the following questions:

(1) Do the convective flow contours for the plasma correspond to contours of constant angular momentum?

(2) Should the angular momentum of the convecting plasma be conserved, i.e., is there a torque on this plasma?

(3) Does the elliptical polarization of the hydromagnetic waves that we observe at ATS-1 correspond to a similar motion of the plasma? If so, can the plasma carry angular momentum in the form of these oscillations?

We are working on computer codes that will help give answers to these questions. Most of the codes are complete, but we still have a few bugs.

Other Matters:

We are enclosing a copy of the catalog of low frequency oscillations for January, 1968. It is incomplete, as we received some additional rolls of microfilm after the catalog was completed. We are revising the catalog now.

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Catalog of Low-Frequency Oscillations of the Earth's Magnetic Field as Observed at ATS-1 During January, 1968

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October 31, 1973

Catalog of Low-Frequency Oscillations of the Earth's Magnetic Field as Observed at ATS-1

During January, 1968

W. D. Cummings and D. Lyons
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Grambling College
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Introduction

The attached catalog of events has been prepared to facilitate a comparison of ATS-1 data with other ground and satellite magnetometer data. We have begun the catalog in March, 1968, when the ATS-1 data begins to overlap data from the DODGE satellite. We hope to eventually catalog all our data for 1967, 1968, and 1969.

Explanation of the Catalog

In this catalog an event is defined as an oscillation of the magnetic field with a duration of at least ten minutes, and a frequency that remains roughly constant. Events are distinguished on the basis of the frequency of the oscillation, e.g., when a high frequency oscillation is superimposed upon a lower frequency oscillation, two events are identified.

The oscillations of an event usually occur in bursts that are typically one hour in duration. In a burst the amplitude of the oscillation begins at a low level, grows to a maximum, and then decreases to a low level again. Because the oscillation begins with a low amplitude, it is often difficult to exactly specify the beginning time of the event.

The beginning time is given in Universal Time. ATS-1 is stationed in the geographic equatorial plane at a geocentric distance of 6.6 R_E and at 150° W longitude. One can easily arrive at the Local Time for the beginning of the event by subtracting 10 hours from the Universal Time (or by adding 14 hours if the hour of the beginning time (U.T.) is less than 10).

Gaps of as much as an hour may occur between bursts in a given event. However, we defind the duration of an event as the time interval between the beginning of the first burst and the end of the last burst.

We have used microfilm copies of the data at 0.32 second averages to measure the time interval between successive peaks. We tried to make at least ten such measurements during an event to determine the average period. In a few cases we were unable to make ten measurements, but in all cases we made at least five. The error figure associated with the average period is the standard deviation of the individual measurements of the period. This error figure is more a measure of the real variability of the time interval between successive peaks than it is of uncertainty in determining that time interval.

The average frequency was determined by inverting each individual measurement of the time interval between successive peaks and then averaging these individual measurements of the frequency. The error figure associated with the average frequency is the standard deviation of the individual measurements of the frequency.

Acknowledgements

Our work is supported by the National Aeronautics and Space Administration through grant NGR-19-011-007.

Low Frequency Oscillations in the Earth's Magnetic Field

Observed at ATS-1

January, 1968

Event No.	Beginning Time (U.T.) Day	Hour	Min.	Duration (Min.)	Average Period T (Sec.)	Average Frequency f (milli-Hz)
01	Jan 01	00	57	126	100.0 ± 12.0	10.1 ± 1.3
02	01	20	00	113	59.5 ± 9.8	17.2 ± 2.8
03	02	00	30	136	72.6 ± 5.2	13.8 ± 1.1
04	02	03	34	60	56.8 ± 9.3	18.1 ± 3.1
05[a]	02	04	45	99	44.0 ± 5.1	23.0 ± 2.7
06	02	12	19	86	66.2 ± 8.1	15.3 ± 1.7
07	02	15	49	51	83.3 ± 6.5	12.1 ± 1.0
08	02	18	20	323	80.5 ± 12.5	12.7 ± 2.0
09	02	19	06	230	354.3 ± 81.3	2.9 ± 0.6
10	03	02	35	70	97.2 ± 11.9	10.4 ± 1.4
11	03	19	20	335	65.8 ± 7.0	15.4 ± 1.7
12	04	02	09	139	88.3 ± 8.2	11.4 ± 1.1
13	04	09	19	44	117.8 ± 8.4	8.5 ± 0.6
14	04	19	52	38	77.5 ± 7.6	13.0 ± 1.3
15	04	21	45	292	133.0 ± 16.2	7.6 ± 0.9
16	05	07	30	25	46.7 ± 3.2	21.5 ± 1.3
17	05	10	52	17	78.9 ± 3.9	12.7 ± 0.6
18	06	02	19	99	83.6 ± 20.4	12.6 ± 3.0
19	06	07	30	85	104.0 ± 11.2	9.7 ± 1.1
20	06	16	29	206	28.8 ± 3.0	35.2 ± 4.1
21	06	21	22	12	68.3 ± 12.4	15.0 ± 2.5

Event No.	Beginning Time (U.T.) Day	Hour	Min.	Duration (Min)	Average Period T (Sec)	Average Frequency f (milli-Hz)
22	06	22	57	62	32.2 ± 2.1	31.2 ± 1.9
23	07	01	40	39	32.0 ± 3.7	31.6 ± 3.9
24	07	18	28	167	27.1 ± 1.6	37.5 ± 2.2
25	08	18	48	250	56.9 ± 6.3	17.8 ± 2.3
26	09	20	54	136	158.4 ± 15.2	6.4 ± 0.7
27	10	20	40	10	31.9 ± 2.6	31.5 ± 2.7
28	10	23	36	14	32.1 ± 3.8	31.5 ± 3.8
29	12	22	52	53	37.9 ± 4.5	26.7 ± 3.4
30[a]	13	05	42	15	55.4 ± 11.2	18.6 ± 3.7
31	13	17	47	119	29.3 + 3.1	34.2 ± 2.5
32	14	23	02	93	69.5 ± 10.2	14.7 ± 2.7
33	15	01	30	37	121.8 ± 17.3	8.4 ± 1.2
34	15	08	31	37	49.4 ± 2.4	20.3 ± 1.0
35	16	00	35	151	142.8 ± 13.4	7.1 ± 0.6
36	16	20	50	61	20.7 ± 3.8	49.8 ± 8.6
37	16	22	36	383	75.9 ± 13.4	13.6 ± 2.9
38	17	12	27	68	67.0 ± 4.8	15.0 ± 1.1
39	17	14	56	242	28.6 ± 6.0	36.3 ± 6.9
40	17	20	15	289	24.0 ± 6.0	44.1 ± 10.3
41	18	02	50	90	112.3 ± 18.3	9.1 ± 1.4
42	18	05	25	87	49.1 ± 6.6	20.7 ± 2.7
43	18	23	09	116	63.9 ± 5.4	15.8 ± 1.3
44	19	00	59	13	28.1 ± 1.9	35.8 ± 2.3
45	19	11	05	90	46.8 ± 1.8	21.4 ± 0.8
46	19	16	16	564	25.8 ± 2.9	39.2 ± 3.9

Event No.	Beginning Time (U.T.) Day	Hour	Min.	Duration (Min.)	Average Period T (Sec)	Average Frequency f (milli-Hz)
47	20	06	28	214	88.4 ± 9.3	11.4 ± 1.3
48	20	08	15	18	44.8 ± 7.1	22.9 ± 4.5
49	20	16	28	228	26.1 ± 2.4	38.7 ± 3.7
50	21	04	15	16	66.3 ± 1.2	15.1 ± 0.3
51	21	23	22	63	57.5 ± 1.9	17.4 ± 0.6
52	23	21	57	203	167.8 ± 12.1	6.0 ± 0.5
53[a]	27	03	55	175	195.4 ± 63.3	5.6 ± 1.8
54[a]	29	00	38	24	66.4 ± 16.0	15.8 ± 3.4
55	29	02	40	124	117.0 ± 81.0	12.6 ± 7.8
56	29	23	45	185	82.5 ± 17.0	12.6 ± 2.5
57	30	04	46	14	174.3 ± 2.2	5.7 ± 0.1
58	30	11	02	82	80.7 ± 6.6	12.5 ± 1.1
59	30	20	02	378	69.8 ± 4.4	14.9 ± 4.9

[a]Measurements made on B_z only.

High resolution data not available from January 21, Hr. 00 to January 27, Hr. 03.